THE UNIVERSITY OF ALBERTA

THE HAPTIC AESTHETIC VALUE OF THE GOLDEN SECTION

by

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Haptic Aesthetic Value of the Golden Section", submitted by John McCurdy Hintz in partial fulfilment of the requirements for the degree of Master of Arts.

Abstract

The golden section is a geometric proportion expressed mathematically as 1:X = X:1-X, or the extreme and mean ratio. The whole is to the larger part as the larger part is to the smaller. The ratio expressed more precisely as 1:1.618+ occurs in pentagons, circles, and decagons, but notably in the golden rectangle, a figure which appears in the history of art more often than can be accounted for by mere coincidence.

The first experimental research on the aesthetic value of the golden rectangle was undertaken by Gustave Theodore Fechner in 1876. He found that people most frequently preferred the golden section to other rectangular proportions. Since that time, numerous empirical studies have generally confirmed Fechner's basic findings, although some studies have questioned his results.

With the exception of Révész (1950), however, all the psychological studies have been in keeping with the assumption that the golden section rectangle is a visually satisfying simple figure. Révész found that blind and sighted persons haptically perceiving various rectangular proportions, including the golden section, preferred the square as most pleasing.

The present study re-examined the findings of Revesz by enlisting congenitally blind, late blind and sighted subjects.

While aesthetic rectangular preferences of congenitally blind subjects questioned the existence of the golden section as a haptically satisfying figure, the preferences of late blind and sighted subjects generally confirmed the haptic aesthetic value of the golden section.

The results thus indicated that the haptic perception of the golden section as an aesthetically pleasing rectangular figure is contingent on experience with the visual world.

Acknowledgments

I wish to express my appreciation to Dr. Thomas M. Nelson, my supervisor, for his warm understanding, guidance and encouragement during this research endeavor. Also, I wish to thank the members of my committee, Dr. Paul Swartz and Professor Norman Yates, for their constructive criticism and cooperation.

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Table of Contents

List of Tables

List of Figures

Introduction

The golden section is a geometric proportion expressed mathematically as 1:X = X:1-X, or the extreme and mean ratio. The whole is to the larger part as the larger is to the smaller. The ratio expressed more precisely as 1:1.618+ occurs in pentagons, circles, and decagons, but notably in the golden rectangle, a figure whose two sides bear the magic relationship to each other; that is, width is to length as length is to the sum of width and length. (See Figure 1)

The length of the golden rectangle in Figure 1 is the incommensurable number 1.618+ and the proportion, when extended, is expressed by the series of numbers: 0.09+, 0.146+, 0.236+, 0.382+, 0.618+, 1, 1.618+, 2.618+, 4.236+, and so on. Each term of this series is the sum of the two preceding terms (Ogden, 1937).

A similar series of whole or commensurable numbers, known as the Fibonacci series, which was named after its medieval discoverer, Leonardo ("Fibonacci") da Pisa, is the following: 1, 1, 2, 3, 5, 8, 13, 21, 34 . . . In this series of numbers each pair of adjacent terms in ratio, for example 8:13::21:34, constantly approaches, though it never quite attains the extreme and mean ratio.

What is especially interesting about this set of approximate golden section ratios is its frequent occurrence in nature. For example, Scott (1951, p. 56) has pointed out that the arrangement of the scales of a pineapple make two sets of spirals around the form. One of the curves is steep and spirals in a counterclockwise direction. The other curve spirals in a clockwise direction and is longer and more gradual. The total number of these two sets of logarithmic spirals form a ratio

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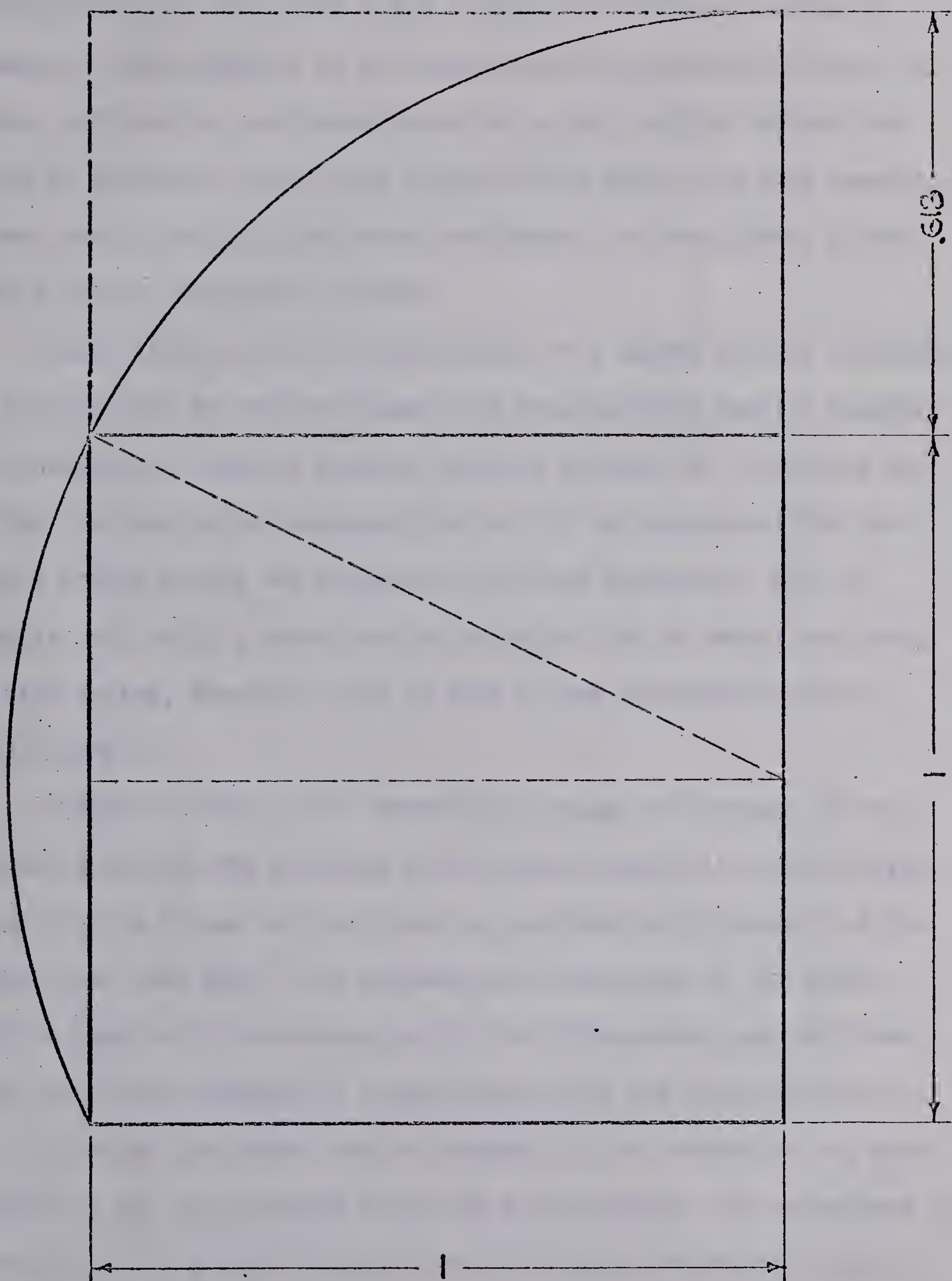

Figure 1

The Golden Rectangle

corresponding to the values 8 and 13 from the Fibonacci series of numbers. Other examples of the occurrence of logarithmic spirals in nature with ratios that approximate the golden section include the curve of elephants' tusks, the horns of wild sheep, and even canaries' claws, not to mention pine cones, sunflowers, and many other plants with a spiral leaf-growth pattern.

Scott (1951, p. 59) has shown that if a golden section rectangle is divided into an endless sequence of progressively smaller squares and rectangular areas by drawing the main diagonal of the figure and a line from one corner perpendicular to it, the squares within the figure rotate around the crossing of the two diagonals. Now, if regular arcs using a corner as center and a side as radius are swung in each square, they will join to form a true logarithmic spiral. (See Figure 2)

Turnball (1956, p. 80) tentatively traces the concept of the golden section to the building of the Great Pyramid in ancient Egypt, at which time it was unlikely that any mathematical statement of the concept had been made. The mathematical expression of the golden section remained to be worked out by the Pythagoreans, who believed that beauty was inherent in simple ratios like the golden section.

Although the golden section appears in the history of art more often than can be accounted for by mere coincidence, its appearance in works of art is primarily associated with those periods of history, notably ancient Greece (5th Century B.C.) and the Renaissance, in which it was believed that a more precise awareness of the beautiful

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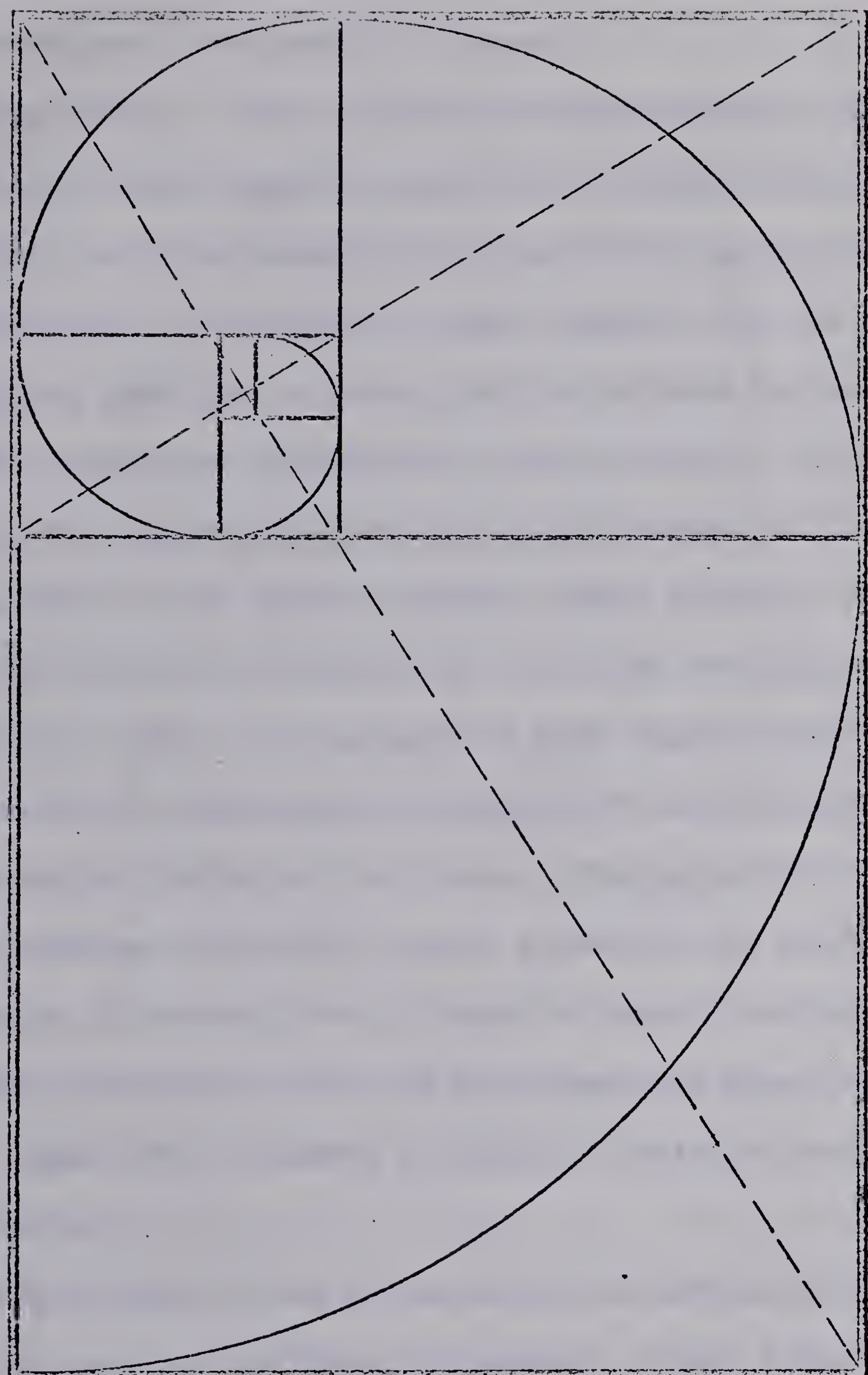

Figure 2

Golden Rectangle with Logarithmic Spiral

could be formulated in mathematical terms.

Huyghe (1959, p. 127) associates the proportions of Doryphorus by Polycleitos, whose Canon of proportions influenced the greatest Greek artists, with the proportions of the human figure according to the golden section. It should be noted, however, that the original Doryphorus has been lost to history and the existent Naples copy is a second or third order reproduction (Sewall, 1953, p. 125). The Parthenon, that ancient Athenian Temple built between 447 B.C. and 432 B.C., fits into the golden rectangle almost precisely if one imagines the structural completion of its ruined rectangular pediment (Scott, 1951, p. 64). It is prudent to note, however, that Hambidge (1920) reports the prevalence of "root-ratios" and not golden section ratios during this period of art history. Rectangles with such ratios have what Hambidge has termed "dynamic symmetry"--the total surface of the rectangle is divisible into a number of exactly similar rectangles. His evidence was obtained from the measurements of Greek vases and temples. Ogden (1937) presents a thorough illustrated discussion of root rectangles.

The application of the golden section to some works of Renaissance art is more obvious (Barry, Bronowoski, Fisher & Huxley, 1964, p. 308; Praeger, 1958, p. 260; Huyghe, 1959, p. 84; Bergamini, 1963, p. 96). Piero della Francessca's Baptism of Christ (about 1440) includes golden section proportions in its geometrically precise composition. Filippo Brunellischi's Capella Pazzi in Florence (begun 1421) was built on the principle of the golden section. Albrecht Dürer used

the golden section in his preliminary sketches for the etching Adam and Eve (1504) to attain "ideal" proportionate harmony in the figures. In the painting St. Jerome (about 1483) by Leonardo da Vinci, a golden section rectangle fits so neatly around the Saint that some experts believe Leonardo purposely painted the figure to conform to the golden section rectangular proportion. This is highly probable considering that Leonardo illustrated Luca Pacioli's treatise on proportion, De divina proportione (1502), which deals with the golden section.

Two works of architecture which circumvent the 14th and 15th centuries and incorporated the golden section are certainly worthy of attention. These are the Court of the Lions in the Alhambra (1309 - 1354) in Granada and the east facade of the Louve (1665) in Paris (Gardner, 1959, pp. 489, 421).

More recently the golden section has been used by the 19th century painters Edgar Degas in Jockey Before the Race (Barry, et al, 1964, p. 47), Georges Seurat in La Parade, and Piet Mondrian in Place de la Concorde (Bergamini, 1963, p. 97). The modern French architect Le Corbusier has also incorporated into the golden section in his work (Arnheim, 1966, pp. 106 - 110).

In the history of Western art the golden section has thus been a source of intrigue, but its aesthetic appeal has been periodic and certainly not universal. Arnheim (1954), for example, makes note of Wolfflin's observation that the baroque style in art "prefers the slimmer or squattier proportions, which contain more tension because

they appear as compressed or drawn-out versions of more simply proportioned oblongs" as opposed to the harmonious and more stable character of the golden section rectangle. (p. 409)

The first experimental work on the aesthetic value of the golden section rectangle was undertaken by Gustave Theodore Fechner (1876). About twenty years previously, Adolf Zeising (1854) had proclaimed that the golden section was the embodiment of a primary aesthetic principle--the combination of a complete diversity in a harmonious unity. According to Zeising the golden ratio was to be found in the beauty of nature, sculpture, architecture and painting, not only in the division of lengths, but also in the ratio of lengths to widths. Chandler (1934), however, has pointed out that Zeising was extremely arbitrary in his application of the golden ratio to the "beautiful" everywhere.

It was just this fact which aroused Fechner's skepticism and caused him to subject the supposed "aesthetic" value of the golden section to the empirical test. He obtained his experimental data by displaying 10 rectangles in a random order to over 200 men and women and asking them which rectangle was the most and the least pleasing. The rectangles were constant in area (80 sq. cm.) and varied in width-length ratios from .40 to 1.00. Fechner analysed his results in the form of a frequency distribution and found that the golden section was the most frequently preferred (35%) rectangular proportion. It should be noted, however, that there was a rather broad mode in Fechner's data ranging from the ratios of .57 to .67 which included about 76%

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rectangular shape was outstandingly pleasing. When he replicated the experiment after two weeks, he found that there was a decided shift in preference toward more narrow rectangles. He concluded that "practice in seeing rectangles induces a demand for more daring ratios." (p. 314)

Two early investigations employing the method of adjustment or production, so that each subject could indicate his exact rectangular preference, have questioned the basic findings of Fechner.

Haines and Davies (1904) arranged a screen with a movable slide so that subjects could make their own rectangles. When the screen was oriented horizontally and the subjects adjusted the length of their preferred rectangle by moving the slide sideways, it was found that the preferred rectangular shape varied from the square to a rectangular width-length ratio of .20. The distribution was also multimodal. When the screen was oriented vertically and the subjects adjusted the height of their preferred rectangle by moving the slide up and down, preferred rectangular width-length ratios were also widely scattered. In both cases, some subjects were consistent in their preferences and others varied considerably.

In another experiment, Haines and Davies (1904) presented rectangles of various sizes one at a time to their subjects and asked them to accept or reject it. There were four series, one with a constant length of 80 mm., the next 90 mm., the next 100 mm., and the last 120 mm. The width varied from 25 mm. to 75 mm. in the first two series by 2.5 mm. intervals, and in the other two series by 5 mm. intervals.

A further variation was introduce by having one series in which the length was horizontal and another in which it was vertical. The results of this experiment, as in the previously cited experiment, emphasized great individual differences in preferences for rectangles. From the subjects' introspective reports, it was shown that very different types of rectangles could be liked by the same individual for one of the following three reasons, all of which have been summarized by Valentine (1962).

> (1) The rectangle was recognized as the appropriate shape of a "calling card" or notebook.
>
> (2) The chosen rectangles fitted in with a special interest of the subject: e.g. "the size I would choose for a canvas on which to paint".
>
> (3) A more objective type of attitude in which the rectangle is judged for itself alone, e.g. "has a wide enough base to hold it up", or "it seems complete in itself." (p. 95)

It is important to note that in emphasizing the significant role of individual differences in their results, Haines and Davies pointed out the error of analyzing highly variable and non-continuously distributed preferential data with the method of averages. Angier (1905) has also pointed out that it is fallacious to look for a "golden section" in the average of the preferences of a number of individuals.

Davis (1933) had over 300 subjects draw their most pleasing rectangle. He found that subjects' preferences ranged from 1.00 to 9.75, with a highest mode at 2.00 and other modes almost equally high at 1.75 and 2.25. Less than 3% of the total number of preferred

proportions were found to be included in the golden section.

In this study Davis interprets his modal values as lending support to the "aesthetic" root rectangular ratios of Hambidge (1920). (see p. 5)

Woodworth (1938) surveyed most of the psychological research on aesthetic preferences for the golden section already cited. In his conclusions he argues against the acceptance of a simple ratio as the ground of preference for the golden section, but he does not disdain all attempts at explanation as the following quote indicates.

> What the subject sees is not a ratio but a shape. In most cases he is unaware of any specific ratio. If he thinks of the rectangle as a visiting card or as having a particular use, his choice will be governed by that idea, but apart from use it would seem that any rectangle is potentially pleasing, the same as any color. (p. 338)

This explanation through association says that a given form is preferred because it resembles forms to which we are already accustomed. It will be recalled that Haines and Davies (1904) cited the association hypothesis as a partial explanation of their results. (see p. 10)

Although many psychologists might agree with Woodworth's explanation, Stone and Collins (1965) maintain that the explanation through association does not satisfactorily account for cross-cultural similarities. Why have so many individuals on at least two continents and over a number of decades shown preferences for rectangles whose metric dimensions are approximations of the golden section? And what has occasioned the perceptual cues of the forms in their origins?

Stone and Collins (1965) have thus attempted to explain preference

for rectangular forms approximating golden section dimensions along the lines of physiological optics. According to them, rectangles with such proportions contain at least 90% of the area within the outline of the binocular visual field when properly oriented. Preference presumably arises because such forms fit the natural binocular condition.

> The fact that the binocular visual field may be regarded as being similar to a rectangle which possesses height and width which corresponds somewhat closely to the properties of the golden section, provides the substance for a hypothesis which attempts to explain why rectangles having proportions similar to that of the golden section are generally regarded as having the most pleasing appearance. (p. 505)

The natural binocular field, it might be mentioned, subtends 200^{o} laterally and 130^{o} vertically (Harrington, 1967).

Along these same lines, Schiffman (1966) assumed that if preference for a given rectangle is determined by the metric dimensions of the visual field, then the preferred orientation of rectangles should also coincide with the horizontal orientation of the visual field.

He instructed 36 subjects to draw their most aesthetically pleasing rectangle and then orient their drawn figures either horizontally or vertically with respect to the long side in the most pleasing position. He confirmed the expected relation between preferred orientation of a rectangle and orientation of the visual field. Ninety-seven percent of the subjects oriented their rectangles horizontally. However, Schiffman experienced difficulty in eliciting drawings of rectangles approximating the golden section. The mean width-length ratio was .525, with a standard deviation of .104, a median of about .500, and a modal

value between .459 and .560.

In reporting the mean width-length ratio as an indicator of preference, it should be questioned whether or not Schiffman has violated the veridicality of the data and thus committed the error of trying to find the golden section in the arithmetical average. Since he neglected to include a frequency distribution of the data, it can only be assumed that the data are not genuinely multimodal. It seems that the median (.500) would be a more representative measure of preference in this case.

In spite of his results, Schiffman concluded that re-examination of the perimetric hypothesis would be desirable using other measures of the binocular field.

Preceding the present study the perimetric hypothesis was re-assessed employing sighted subjects and modern opthamological equipment. The experiment permitted (a) correlating the width-length ratio of each subject's preferred chosen rectangle with the width-length ratio of his mapped visual field's "average rectangle" (Stone and Collins, 1965) and (b) determining the figural orientation of each subject's preferred drawn rectangle.

The results (Hintz and Nelson, 1969) did not confirm the perimetric hypothesis. Chosen and drawn rectangles compared closely in value, but ranged in width-length ratios from .20 to 1.00 and .19 to .98 respectively. In general the width-length ratios of chosen and drawn preferences were less than the golden section ratio. The median for chosen preferences was .558, and the median for drawn preferences was .545.

Since skewing toward lower values was present, the modal values tended to approximate golden section dimensions more closely, particularly for the choice data. The mode was .60 for chosen preferences and .57 for drawn preferences. The mode included 25% and 20% of the cases respectively. In the limits .55 - .65 which includes the golden section, the percentage of subjects became 40% in both cases.

Orientation data were not in close agreement with those of Schiffman and thus questioned the relation posited between response orientation and visual field orientation. Only 80% of the subjects oriented their drawn rectangles horizontally. One subject preferred a vertical orientation, and 3 subjects oriented their drawings to the shape of a diamond.

The coefficient of correlation between the width-length ratio of each subject's chosen rectangle and the width-length ratio of his mapped visual field's "average rectangle" as .279, indicating little relationship between the variables.

Graphic inspection of the data also showed that the range of the two variables was distinct. Hintz and Nelson thus concluded that the theoretical expectation was not borne out. Rectangular preferences could not be reduced to characteristics of the binocular visual field.

The suggestion that aesthetic preference for approximate golden section rectangles was related to the mathematical limits of the binocular visual field was in keeping with the assumption that the golden section is a visually satisfying figure.[1] However, is

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1 A number of other older theories were developed and are dealt with by Haines and Davies (1904) in their early review.

the aesthetic value of the golden section limited to the visual sense or does it also extend to experience evoked by stimulation of other modalities such as the haptic sense?

Révész (1950) became interested in this question as a result of his work on the nature of haptic perception and the aesthetic experience of haptics. In his book Psychology and Art of the Blind, Révész concludes from extensive research with blind and sighted subjects that the discriminating difference between haptic and visual perception is primarily the distinction between whether the percept is simultaneously comprehended or successively recognized. In visual perception apprehension of the object is immediate, simultaneous, spontaneous and comprehensive, whereas in haptic perception apprehension takes place sequentially and is oriented toward the recognition of parts. The center of this distinction between haptic and visual perception provides the basis for his understanding of the nature of aesthetic experience, for according to Revesz, the basic condition of all aesthetics is the unified and spontaneous apprehension of form. He says:

> Through our comparative experiments we have reached the conclusion that the way in which the blind perceive, recognize, and appreciate plastic works is not due to the mere fact that they are blind and lack visual concepts, but exclusively to the special nature of the haptic process of perception and recognition, a process which takes place in an almost identical manner both in blind and sighted subjects. So it does not make any difference whether we are dealing with sighted subjects trained in haptic methods, or with subjects born blind or late in life, or with the degree of education among observers. Admittedly there are differences of type and

> individual differences, but there is complete similarity in respect to haptic perception, recognition and interpretation. In view of the fact that a total image of haptically observed objects, representing the complete morphological and phenomenological significance of the data, cannot be obtained, it seems justifiable to assume that in the field of Haptics one can hardly speak of an aesthetic appreciation in the stricter sense ......
> The fundamental condition of any aesthetic view of a work of art is the apprehension of artistic values. It is not through knowledge or recognition that we achieve an insight into the aesthetic value of a work, but through the spontaneous experience of the artistically beautiful. The aesthetic experience seems, however, to be entirely incompatible with the basic character of haptic apprehension, with the analytical and constructive nature of the object. If we could, by way of analysis, attain a vivid apprehension of the work of art, it would be possible to find in the field of Haptics also an approach to aesthetics. But an exhaustive comprehension is only possible to a very limited extent in the haptical world of forms, whatever the "Hapticists" and some psychologists of the blind may enthusiastically assert; the fragmentary material, with its undeveloped formal structure, is far from yielding all the vividness of the object to the aesthetic approach. (pp. 201 & 202)

Since Révész concluded that in the field of Haptics aesthetics is limited to the most simple structures and part-structures, he was naturally interested in the question of whether objects which lie within the range of simple structure are open to aesthetic appreciation. In pursuing this question the Danish psychologist subjected Fechner's findings on the relative aesthetic value of the golden section to further investigation

In an experiment with sighted subjects he not only used Fechner's series of ten rectangles, but also constructed a series of larger and smaller rectangles which differed from one another in height. Révész found that in Fechner's series of rectangles, as well as his own,

most subjects preferred the rectangle with golden section sides (1:1.6): "occasionally proportions coming very close to it were chosen - example: 1:1.55 and 1:1.65 and rarely 1:1.7, and quite exceptionally a proportion below the golden section, i.e. in the direction of a square - was selected" (p. 199). However, when Revesz presented the same series of rectangles to the sense of touch, he found that blind as well as sighted subjects perceiving purely haptically selected with few exceptions, not the golden section but the <u>square</u>, or a rectangle very similar to the square. From this result, Révész drew the following conclusion:

> It would be a mistake to assume that the preference shown in respect to the square is connected with an aesthetic impression; this selective act is rather determined by the 'metric principle.' Since the metrical proportions play a decisive part in the field of Haptics, and since among the simultaneously presented rectangles the square occupies a position of its own as metrically the simplest figure, it is understandable that our subjects should select the square. From the haptic point of view the square is of all rectangles the easiest figure to grasp, it is the most convenient figure for being apprehended by movements following the outlines, it is the simplest figure from the point of kinaesthetic rhythms, and the figure which is most easily retained in memory, apart from having the advantage of saving us the trouble of tediously examining proportions. (p. 200)

In reducing the "aesthetics" of haptics to sensory impressions perceived in the stimulus structure of simple forms, Révész ignored the possible influence of the perceiver's visual organization as a determinant of any aesthetic judgment based on haptic perception. The haptic aesthetic percept of a given simple form is made to reside

in the structure *qua* structure of that form and not in the experiencing organism.

The blind psychologist Cutsforth (1951) pursued another tack. In his discussion of aesthetics with reference to the blind he maintained that the stimulus pattern or the objective aspect of haptic perception is the smallest part of any aesthetic experience. The greatest part of the experience is the perceiver's subjective organization of a myriad of affective relationships about the stimulus pattern. "An aesthetic judgment is a meaningful whole to which the self contributes the greater part." (p. 169) Thus, although Cutsforth maintains that there are probably conditions in a given tactual stimulus pattern that should produce common affective values for sighted and blind alike, he holds that "the amount of visual organization present determines the subjective nature of every tactual experience." (p. 183) The subjective nature of *any* tactual experience for a congenitally blind person who lacks visual imagery would therefore differ from that of a blind person who lost his sight after having contact with the visual world.

The study to be reported was designed to study form preferences of both blind and sighted subjects in order to subject the phenomenon to further investigation.

Due to the explanatory nature of the research, specific hypotheses were unfortunately not proposed. It should be noted, however, that the type of analysis Révész provides predicts that (a) sighted subjects perceiving haptically and visually will aesthetically prefer

most frequently the square and the golden section respectively as the most pleasing rectangular figure, and that (b) congenitally and late blind subjects perceiving haptically will aesthetically prefer most frequently the square as the most pleasing rectangular figure. Reasoning from Cutsforth's position leads to a prediction that differences among congenitally blind, late blind and sighted subjects will occur with the latter two groups being similar, but different from the congenitally blind.

Method

Subjects

Four groups of subjects served. The groups were: (1) congenitally blind (N = 20, Males = 9, Females = 11); late blind (N = 20: Males = 11, Females = 9); (3) blindfolded normal sighted (N = 40: Males = 20, Females = 20); and (4) non-blindfolded normal sighted (N = 20: Males 10, Females 10). The non-blindfolded sighted subjects were randomly selected from the blindfolded sighted subjects.

The following criteria were used in selecting blind subjects from the Canadian National Institute for the Blind: (a) a chronological age of 17 years of higher; (b) opthamologically diagnosed as possessing no more than light perception, and (c) absence of evidence of brain damage. Onset of blindness for congenitally blind subjects was at birth or before 5 years of age (Löwenfeld, 1963, p. 231). Onset of blindness for late blind subjects was after 7 years of age. In actuality all congenitally blind subjects were blind before the age of 2½ years. All late blind subjects were not blind prior to 10 years of age.

Normal sighted subjects making up groups (3) and (4) above, were drawn from University of Alberta students and University of Alberta non-academic employees so as to be matched for age and sex with the blind subjects of groups (1) and (2).

Apparatus

Visual and tactual rectangular outlines with constant areas of 81 sq. cm. and width-length ratios of .10, .20, .30, .40, .45, .50,

.55, .60, .65, .70, .75, .80, .90, and 1.00 serves as stimuli.[2] (See Figure 3) Visual rectangles were drawn with black ink on 10" x 12" off-white paper. Tactual rectangles were engraved in 10" x 12" durable gloss paper, and their outlines were filled with contact cement. They were then mounted on cardboard. Tactual stimuli were presented using a 12" square box which secured targets on four sides. The box swiveled and was equipped with a brake fixing the target in the appropriate inspection position. (See Figure 4)

Visual rectangles were presented from a distance of 40"--eye to target--behind a 24" x 25" black cardboard field stop. Binocular viewing apertures were ½" in diameter, 38" from the floor, with an interocular distance of 57 mm. Target center was also 38" from the floor and illumination at the eye was 23 footcandles as measured by a Weston Illumination Meter - Model 756.

Procedure

Normal sighted subjects were tested in an experimental cubicle; blind subjects in their homes.

For the tactual test subjects were comfortably seated at a table in front of the swivel box, and normal sighted subjects blindfolded. Following this, instructions were read:

> This is an experiment in which I am trying to investigate aesthetic preferences for rectangles which are perceived using the sense of touch. The nature of the task is as follows: On any

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2 In a pilot study it was determined that congenitally blind, late blind and blindfolded sighted subjects could tactually discriminate a rectangular width-length ratio difference of .05 cm. Thus, the smallest width-length ratio difference between two rectangles was .05 cm.

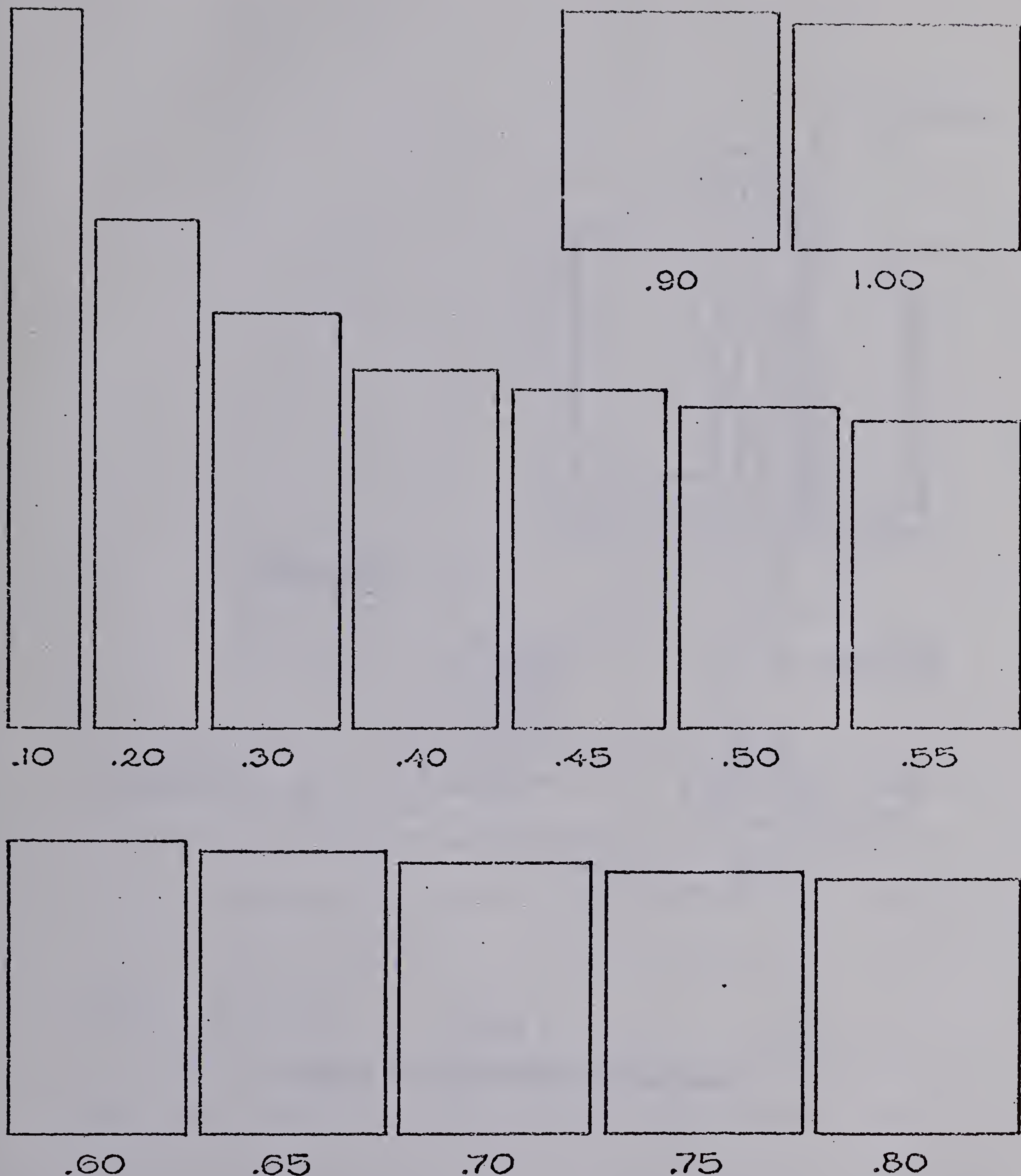

Figure 3

Rectangular Width-Length Ratios of
Experimental Stimuli

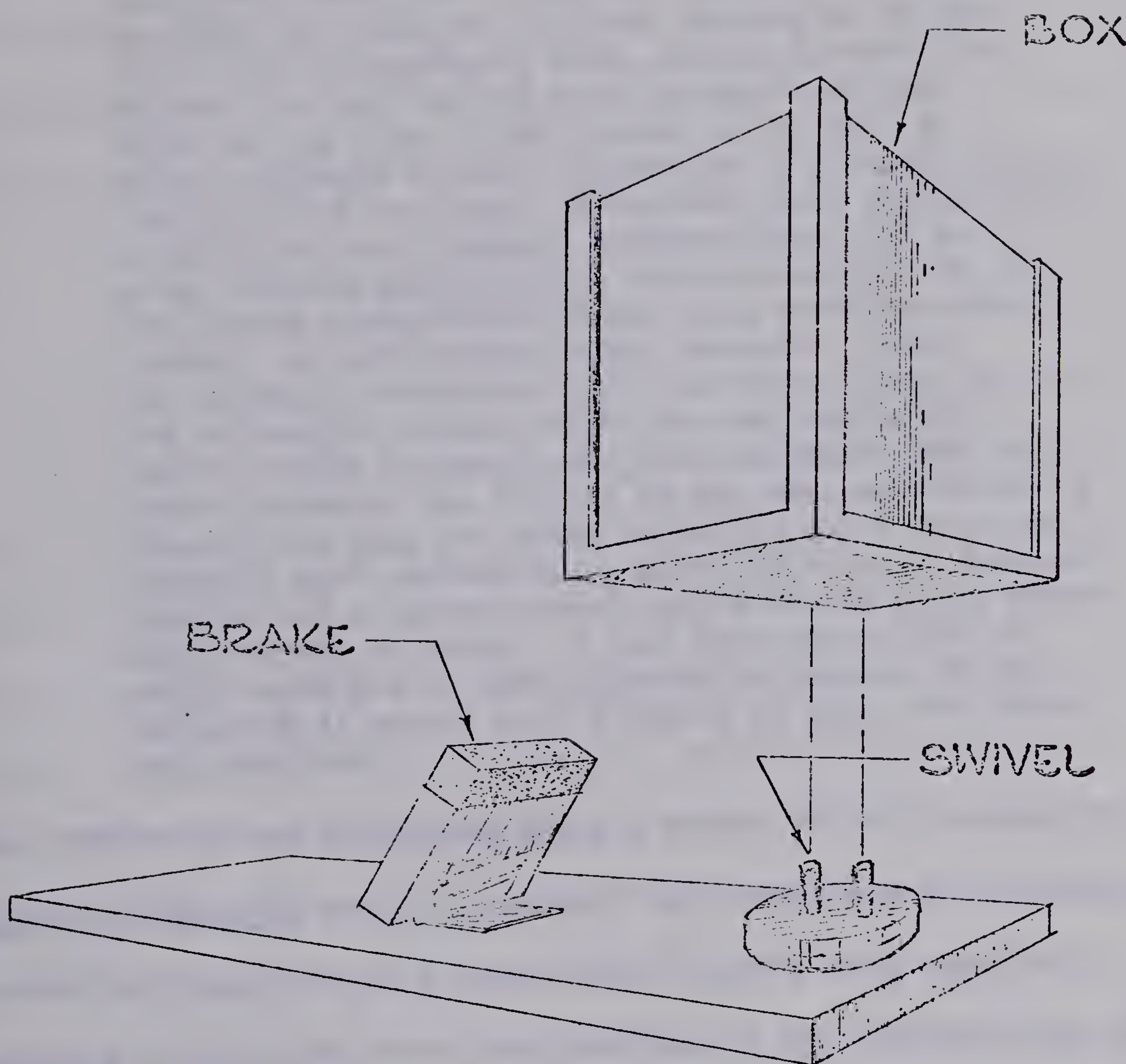

Figure 4

Diagram of Experimental Apparatus

> given trial I shall present to you three cards successively; that is, one card at a time from a whole series of cards on which rectangles have been inscribed in outline form. I want you to touch and feel the outlined rectangles on each card with you preferred hand, taking as much time as you like and feeling each rectangle as many times as you like. Then I want you to tell me which rectangle is most aesthetically pleasing to you and which rectangle is secondly most aesthetically pleasing to you. Several presentations will be given lasting approximately thirty minutes, and for any single presentation there is no right or wrong answer. On each presentation, however, I want you to make a conscious effort to concentrate on the rectangles placed before you and then simply tell me which rectangle you like the most; that is, which rectangle you find to be the most aesthetically pleasing to you, and which rectangle you find to be secondly most aesthetically pleasing to you. Remember this is not a psychological test with any given answer, either right or wrong. I just want you to tell me which rectangle is most pleasing to you and which rectangle is second most pleasing to you. Are there any questions?

After preference was determined using a method to be discussed in the Analysis of Response section, subjects were asked why they preferred a particular rectangle, and their verbal reports were recorded. Previously cited instructions were adopted to the sighted group which was tested after a five minute adaptation period.

Analysis of Response

Aesthetic preference was determined by a 3-stage process of successive elimination. This proceeded in the following manner. Subjects were initially presented with the permutations of three rectangles, .30, .60 and .80, representing a sample of the extremes and middle of the stimulus continuum, and first and second choices were recorded. Presentation positions were randomized and the

criterion for preference was the rectangle chosen first two-thirds of the time in a minimum of 6 trials. This determined which three rectangles would be presented on the next 6 trials. The next three rectangles clustered around the first and second choices more satisfactorily. If the preferential rectangle order for trials one to six was .30 (1), .60 (2), and .80 (3), as contrasted with .60 (1), .80 (2), and .30 (3) for example, then the permutations of rectangles .20, .50, and .65 would be presented for the next 6 trials and not rectangles .45, .60, and .75. Note that in the former case smaller width-length ratios have been emphasized thru elimination, whereas in the latter case larger width-length ratios are emphasized.

Using this procedure it proved possible to determine each subject's preference within a range of 5 rectangles by trial 12. These 5 rectangles were then presented 3 at a time in all possible combinations for 10 trials. For example, if after trial 12 subjects preferred .50 (1), .20 (2) and .65 (3), then the 5 rectangles presented for trials 13 - 22 would be narrowed to .40, .45, .50, .55, and .60. The rectangle preferred most frequently would be rendered the subject's final preference.

The rule of thumb followed continuously throughout this procedure was the successive elimination of those ratios not in the immediate surround of a subject's first and second preference, while maintaining a range of possible ratios to choose from which maximized the importance of the direction of the second preference.

This rule of thumb, however, did not apply when preferences were inconsistent. Inconsistency occurred when a subject chose for his first and second preferences width-length ratios which were extreme with respect to one another. For example, if a subject's preference at the completion of the first set of trials was .30 (1), .80 (2) and .60 (3), or .80 (1), .30 (2) and .60 (3) he was inconsistent. In such cases of inconsistency, the range of rectangular ratios presented centered around the subject's first preference.

As further information on the procedure, Table 1 presents the preferential orders for rectangles in Stage I which determined the rectangles to be presented in Stage II. Table 2 presents the possible preferential orders for rectangles in Stage II, given Stage I preferences, which determined the five rectangles to be presented in Stage III.

Table 1

Possible Preferential Orders for Rectangles in Stage I Determining the Rectangles to be Presented in Stage II

Stage I Preferential orders for rectangles exhibited by subjects.			Stage II Rectangles for presentation given Stage I preferences.		
First	Second	Third			
.30	.60	.80	.20	.50	.65
.60	.80	.30	.45	.60	.75
.80	.60	.30	.50	.65	.90
.60	.30	.80	.45	.55	.70
.30	.80	.60	.10	.40	.55
.80	.30	.60	.65	.75	1.00

Table 2

Possible Preferential Orders for Rectangles in Stage II Given Stage I Preferences, and Determining the Five Rectangles to be Presented in Stage III.

Stage II Rectangles for Presentation given Stage I preferences			Stage II Preferential Orders for Rectangles exhibited by subjects			Stage III's 5 rectangles for presentation given Stage II preferences				
			First	Second	Third					
.20	.50	.65	.20	.50	.65	.10	.20	.30	.40	.45
			.50	.65	.20	.45	.50	.55	.60	.65
			.50	.20	.65	.40	.45	.50	.55	.60
			.65	.50	.20	.55	.60	.65	.70	.75
			.65	.20	.50	.60	.65	.70	.75	.80
			.20	.65	.50	.10	.20	.30	.40	.45
.45	.60	.70	.45	.60	.70	.40	.45	.50	.55	.60
			.60	.70	.45	.55	.60	.65	.70	.75
			.60	.45	.70	.45	.50	.55	.60	.65
			.70	.60	.45	.60	.65	.70	.75	.80
			.70	.45	.60	.60	.65	.70	.75	.80
			.45	.70	.60	.30	.40	.45	.50	.55
.50	.65	.90	.50	.65	.90	.45	.50	.55	.60	.65
			.65	.90	.50	.60	.65	.70	.75	.80
			.90	.65	.50	.70	.75	.80	.85	.90
			.65	.50	.90	.55	.60	.65	.70	.75
			.50	.90	.65	.40	.45	.50	.55	.60
			.90	.50	.65	.70	.75	.80	.85	.90
.45	.55	.70	.45	.55	.70	.30	.40	.45	.50	.55
			.55	.70	.45	.50	.55	.60	.65	.70
			.55	.45	.70	.45	.50	.55	.60	.65
			.70	.55	.45	.55	.60	.65	.70	.75
			.70	.45	.55	.60	.65	.70	.75	.80
			.45	.70	.55	.30	.40	.45	.50	.55

Table 2 (Continued)

.10	.40	.55	.10	.40	.55	.10	.20	.30	.40	.45
			.40	.55	.10	.30	.40	.45	.50	.55
			.40	.10	.55	.10	.20	.30	.40	.45
			.55	.40	.10	.40	.45	.50	.55	.60
			.10	.55	.40	.10	.20	.30	.40	.45
			.55	.10	.40	.45	.50	.55	.60	.65
.65	.75	1.00	.65	.75	1.00	.55	.60	.65	.70	.75
			.75	.65	1.00	.60	.65	.70	.75	.80
			.75	1.00	.65	.70	.75	.80	.90	1.00
			1.00	.75	.65	.70	.75	.80	.90	1.00
			.65	1.00	.75	.55	.60	.65	.70	.75
			1.00	.65	.75	.70	.75	.80	.90	1.00

Results

Aesthetic preferences of all subjects were found to cover the entire range of width-length ratios from .10 to 1.00. No sex differences were observed from perusing the data. Table 3 shows the modal and median values for all groups. Notice that late blind tactual preferences are closest to golden section values. Sighted subjects are very nearly the same for tactual as for visual forms but both somewhat less than the late blind. The congenitally blind group is still more deviant in this regard.

Figure 5 presents results graphically in the form of frequency polygons. Note that in the limits .55 - .65, which includes the golden section, the percentage of non-blindfolded sighted, blindfolded sighted, late blind and congenitally blind subjects preferring these ratios is 40%, 37.5%, 30% and 10% respectively. The polygon of congenitally blind subjects thus shows a large pile-up of preferences at the "narrow form" end.

From the findings just cited, it appears that sighted subjects perceiving haptically as well as visually preferred an approximate golden section rectangle over the square. The Wilcoxon Matched-Pairs Signed Ranks Test (Siegel, 1956, pp. 75 - 81) was used with these data (See Table 4) to determine whether haptic and visual preferences of the sighted group differed significantly in this respect. Analysis was performed with each subject acting as its own control. Since the calculated value of T = 27.5 was not equal to or less than 21, the critical value required for a two tailed test of significance at a = .05, the null hypothesis was not rejected. This analysis is thus inconsistent

Table 3

Mode and Median Values for Haptic and Visual Preferences

	Congenitally blind	Late blind	Blindfolded sighted	Non-blindfolded sighted
Mode	.10	.60	.60	.60
Median	.500	.615	.575	.558

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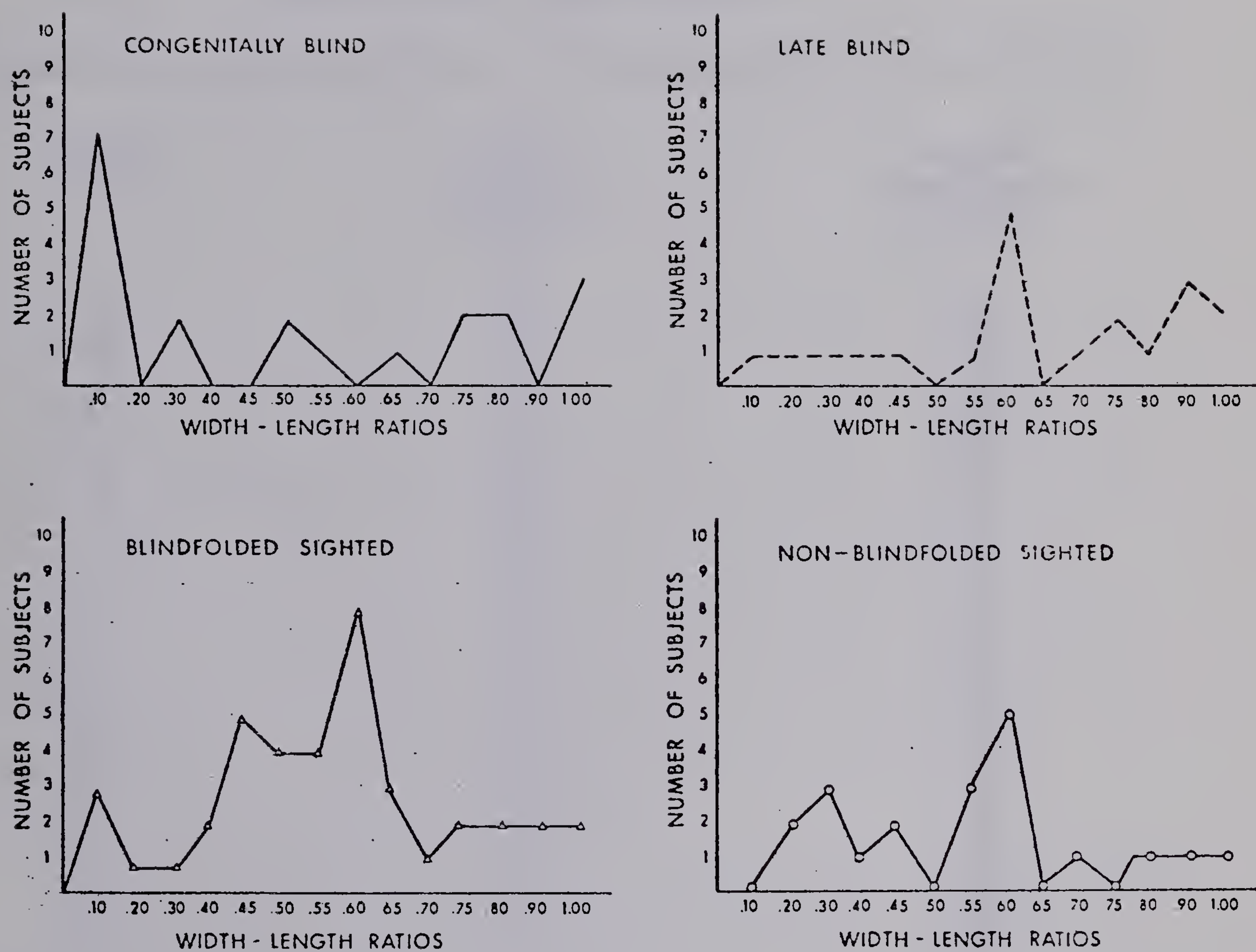

FIGURE 5

FREQUENCY POLYGONS COMPARING PREFERENCES OF CONGENITALLY BLIND, LATE BLIND, BLINDFOLDED SIGHTED, AND NON-BLINDFOLDED SIGHTED SUBJECTS FOR THE MOST AESTHETICALLY PLEASING RECTANGLE.

Table 4

Haptic and Visual Rectangular Preferences of

Twenty Normal Sighted Subjects

Subject	Haptic preference ratio	Visual preference ratio
1	.40	.45
2	.55	.45
3	.45	.30
4	.70	.70
5	.65	.60
6	1.00	.90
7	.45	.20
8	.60	1.00
9	.20	.20
10	.45	.55
11	.40	.40
12	.50	.55
13	.60	.60
14	.50	.30
15	.90	.80
16	.60	.60
17	.45	.30
18	.65	.60
19	.60	.55
20	.60	.60

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[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]

with the results of Révész, who found that sighted subjects perceiving rectangles haptically and visually preferred as most pleasing the square and the golden section respectively. Appendix A presents the data and the calculation of T.

Because congenitally blind, late blind, and blindfolded sighted subjects did not most frequently prefer the square, it was decided to test for significant deviations from the golden section. Accordingly, the Kruskal-Wallis One-Way Analysis of Variance by Ranks, a nonparametric test for K independent samples based on the statistic H (Siegel, 1956, pp. 185 - 194) was applied to the data. Results disclosed that with $H = 8.733$, $df = 2$ and $\alpha = .05$, $p < .02$. Thus, the proportion preferences of congenitally blind, late blind, and blindfolded sighted subjects differ reliably from one another in their deviations from the proportions of the golden section, and the null hypothesis must be rejected. This analysis is inconsistent with the position taken by Révész and consistent with the prediction of Cutsforth so far as these can be developed.

According to Révész, most haptic preferences of blind and sighted subjects would have uniformly deviated from the golden section by an approximate constant of .38, the deviation value between the square and the golden section, since he found these subjects most frequently preferred the square as the most pleasing rectangular figure.

Cutsforth's writing leads one to predicted differences among congenitally blind, late blind, and sighted subjects with the latter two groups being similar, but different from the congenitally blind. But, it will be recalled that Cutsforth did not study rectangular preferences among the blind.

Discussion

Preference data obtained from late blind and blindfolded sighted subjects generally confirmed the haptic aesthetic value of the golden section. However, preferences of congenitally blind subjects call into question the existence of the golden section as haptically satisfying simple figure. It should be noted that a larger sample of blind subjects would have increased the reliability of these results.

With the partial exception of late blind subjects, the preferential data cast doubt upon the conclusions of Révész (1950). Although late blind subjects preferred the golden section (See Figure 5), 25% also preferred rectangular width-length ratios of .90 or 1.00. All other subjects operating on haptic rather than visual input did not most frequently prefer the simplest rectangular figure, or some rectangle very similar to the square. It thus seems highly questionable whether the "metric principle" plays the decisive role that Révész attributes to it in determining preferences for simple rectangular forms perceived haptically.

Alternatively, it could be considered that the non-equivalent findings of the present study and those of Révész were due to a difference between the stimuli and the method used in the two studies. It is impossible to compare in detail the findings of the two studies however, since as far as this author knows Révész only reported his results very generally in Psychology and Art of the Blind (1950). (see p. 16)

It is especially interesting to note that each of the two series of rectangles Révész presented to subjects consisted of 26 figures. Presumably the method Révész used to determine each subject's preference was at least similar to Fechner's method in which subjects

chose their most pleasing rectangle from the entire series of rectangular figures presented. If this is in fact the case, then in all likelihood Révész's results were probably confounded with a memory factor; that is, any given subject's ability to recall which of 26 rectangular figures was haptically most pleasing. Perhaps Révész's subjects preferred the square as most pleasing solely because it was the simplest form to remember.

In his discussion on the interrelation of the sense modalities (Bartley, 1958) makes the following observation:

> Each sense modality provides for two functions: a direct experiential result ensuing form stimulation of sense organs, and an associated result we call imagery. Imagery is the experiencing of objects and all that pertains to them, either by way of memory or by way of association with some modality that is not being activated through its own sense organs. (p. 60 - 61)

This is similar to the contention of Cutsforth (1951) that the amount of visual organization present determines the subjective nature of any tactual experience and that therefore congenitally blind must be considered as a special group of perceivers because they have lacked contact with the visual world totally. The fact that preferences of congenitally blind, late blind and blindfolded sighted subjects significantly differed from one another in their deviations from the golden section is attributable to the fact that 35% of the congenitally blind subjects preferred a rectangular width-length ratio of .10. It would therefore seem that visual imagery may have played the decisive role in determining haptic preferences.

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In agreement with the latter interpretation, Löwenfeld (1963) has cited several studies (Toth, 1930; Schlaegel, Jr., 1953; Blank, 1958) showing that individuals who have lost their sight before the age of between 5 and 7 years do not retain any useful visual imagery. Related to this, Sylvester (1913) used a form board test on 85 blind subjects and found that those lacking visual experience showed the least ability, and that the longer each subject had been able to retain his vision, the more successful he was in the test. He declares that "those who have had visual experience retain their visual imagery and are assisted by it in the interpretation of their tactual impressions; and tactual imagery, even in those who have no other resource, is not as effective as a combination of tactual and visual imagery." (p. 200)

Likewise, Worchel (1951) in a study attempting to determine the role of visualization in tactual form perception found that while there were no significant differences between congenitally blind, late blind, and sighted subjects in their ability to recognize simple geometric forms by selecting among four blocks the one that was similar in shape to the stimulus block, a finding confirmed by Ewart and Carp (1961), subjects did, however, differ in their ability to reproduce their tactual perceptions with drawings as well as describe them. Sighted subjects were significantly better than the congenitally blind. He also interprets this as indicating that touch alone is not as efficient in the perception of simple tactual forms as touch aided by visual images.

The cognitive processes of blind subjects involved in making preferential aesthetic judgments about simple rectangular forms are

probably quite similar to those used by blind subjects to reproduce (draw) and describe a simple geometric form. In this study a systematic rating analysis of the visual imagery used by the blind subjects in their introspective reports on why they preferred a particular rectangle was not undertaken. It was generally observed, however, that while late blind subjects made substantial use of visual imagery in their verbal reports, congenitally blind subjects did not. The following examples of verbal reports illustrate this observation: Congenitally blind: "Fatter shapes represent durability, quality, stability." "Just like the way it is, it's nice." "Don't really know; I like it." "less rigid, a free flowing form, like a voice that flows." "A square has no beauty." Late Blind: "I visualized picture frames and books; it's the size of a snapshot." "The proportions are pleasing, like electrical switch covers." "There is more use for a narrow rectangle, like a name plate or a door slot." "Perceived it with reference to a frame; it's like a playing card." "Like linoleum tiles--they all fit; you get uniformity--nothing is offset."

In noting the biological importance of vision as a special sense, Critchley (1952) writes that "even in those who lose their sight at a relatively early age, a visual type of thinking may continue or at any rate, it may modify the kind of imagery." (p. 27)

In light of this discussion, the results of this study may be interpreted as evidence that haptic perception of the golden section as an aesthetically pleasing rectangular figure depends on experience with the visual world as opposed to the haptic perception of any positive affective value the figure has inherent in its structure.

Additional support for this conclusion can be offered from the developmental research findings of Thompson (1946) and Shipley, Dattman and Steele (1947) on preferences for rectangular proportions.

Thompson investigated age differences in preference for rectangular proportions. He had four chronological age groups--pre-school (2 - 5 years), third grade (8 - 10 years), sixth grade (10 - 14 years) and college (17 - 23 years)--rank 12 rectangles of uniform length for their aesthetic pleasingness. The rectangles were not constant in area and ranged in width-length ratios from .25 to .75.

The data, which were reported as median ranks, revealed that the pre-school group showed no consistent rectangular preferences, while the two school-age groups, with the exception of a slight inversion between the two narrowest rectangles, showed an increasing preference for rectangles with larger width-length ratios. On the other hand, the college group showed an increasing preference for rectangles up to the width-length ratio of .55 with a slight decrease in preference for the ratios .60 and .65, and then declined markedly for the higher ratios. These results on adult subjects are generally consistent with the findings of earlier investigators previously reviewed in this paper.

Since the area of Thompson's rectangles increased with their width, Shipley et al, (1947) thought that the results might have been influenced by the size of the rectangles. They thus investigated preferences for rectangular proportions in children and adults using two series of 6 rectangles--one with length held constant and the other with area held constant.

The results generally confirmed the rectangular preference trends reported by Thompson for children and adults, although it was found that children tend to prefer larger rectangles while adults incline toward a more medium sized rectangle.

The findings of both these two studies emphasize the importance of experience with the visual world in influencing the development of aesthetic preferences for rectangular proportions. Likewise, the outcome of the present study also emphasized the importance of contact with the visual world.

It still remains, however, to offer a tentative explanation of why congenitally blind subjects (35%) most frequently preferred a rectangular width-length ratio of .10, which is completely asymmetrical with respect to the square. This finding was contrary to the expectations voiced by Revesz that the square would be preferred over other rectangular figures because it has simple kinesthetic rhythms.

Cutsforth (1951) noted that the blind frequently produce self-stimulation kinesthetically through "bodily swaying, rolling or tilting the head, arm motion and shoulder shrugs, and exaggerated genuflections." (p. 6) This automatic self-stimulation he calls "blindisms." One might infer from this study that the frequent preferences of congenitally blind subjects for long narrow rectangles may not have been based on the "aesthetic" value of the stimulus structure <u>per se</u>, but upon an increase in the amount of kinesthetic stimulation received thru tracing the outline of the figure. In short, the haptic perceptual exploration of long narrow rectangles provides more greatly contrasting kinesthetic rhythms than the simple kinesthetic rhythms of

the square. Cutsforth (1951) expresses much the same idea when he says, "there is much evidence from preliminary investigations that changing form possesses the greatest tactual aesthetic value." (p. 184)

It is thus suggested that future studies investigating the haptic aesthetic value of various forms for the blind experiment with what I shall refer to as "changing" and "non-changing" forms.

Changing and non-changing forms differ from one another in the quality of their material substance as opposed to their stimulus structure. The material substance of a changing form in general lends itself to movement and elastic flexability without losing its shape. Its substance quality is dynamic as opposed to static, and as such it is the greater contributor to sensory stimulation of the tactual modality than its structure. Perhaps the best example of what is meant by a changing form is the living human body.

On the other hand, the material substance of a non-changing form is stable and non-flexible. The quality of its substance is static. In perceiving a non-changing form haptically, the greater contributor to sensory stimulation of the tactual modality is the structure of the form and not the material substance from which it is made.

Substances like foam rubber, leather and soft plastics would provide excellent materials for the construction of changing forms, whereas materials like wood and metal could be used to construct non-changing forms.

It would be understood, however, that the substance of any form is not mutually exclusive from its structure, but both parts comprise

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the larger whole we call form. It therefore seems likely that forms which would have optimal haptic aesthetic value for the blind would be those which maximize haptic sensory stimulation in their structure-substance.

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Appendix A

The Wilcoxon Matched-Pairs Signed Ranks Test for Haptic and Visual Preferences of 20 Normal Sighted Subjects

Subject	Haptic preference ratio	Visual preference ratio	Difference (d)	Rank of (d)	Rank with less frequent sign
1	.40	.45	-.05	-3	3
2	.55	.45	.10	7.5	
3	.45	.30	.15	10.5	
4	.70	.70	0		
5	.65	.60	.05	3	
6	1.00	.90	.10	7.5	
7	.45	.20	.25	13	
8	.60	1.00	-.40	-14	14
9	.20	.20	0		
10	.45	.55	-.10	-7.5	7.5
11	.40	.40	0		
12	.50	.55	-.05	-3	3
13	.60	.60	0		
14	.50	.30	.20	12	
15	.90	.80	.10	7.5	
16	.60	.60	0		
17	.45	.30	.15	10.5	
18	.65	.60	.05	3	
19	.60	.55	.05	3	
20	.60	.60	0		
					T = 27.5
					N = 14

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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Appendix B

Kruskal-Wallis One Way Analysis of Variance on Deviations of Preferences from the Golden Section for Congenitally Blind, Late Blind, and Blindfolded Sighted Subjects

Congenitally Blind		Late Blind		Blindfolded Sighted	
Preference ratio	Deviation score	Preference ratio	Deviation score	Preference ratio	Deviation score
.80	.18	.90	.28	.60	.02
.75	.13	.45	.17	.50	.12
1.00	.38	.80	.18	.80	.18
.10	.52	.75	.13	.10	.52
.10	.52	.90	.18	.75	.13
.75	.13	.40	.22	.60	.02
.10	.52	.20	.42	.10	.52
.30	.32	.60	.02	.50	.12
.10	.52	.10	.52	.55	.07
1.00	.38	.55	.07	.80	.18
.10	.52	1.00	.38	.10	.52
.10	.52	.60	.02	.65	.03
.10	.52	.60	.02	.55	.07
.80	.18	.60	.02	.60	.02
.50	.12	.70	.08	.55	.07
.50	.12	1.00	.38	.90	.28
.55	.07	.60	.02	.45	.17
.65	.03	.90	.28	.75	.13
1.00	.38	.75	.13	.30	.32
.30	.32	.30	.32	1.00	.38
				.40	.22
				.55	.07
				.45	.17
				.70	.08
				.65	.03
				1.00	.38
				.45	.17
				.60	.02
				.20	.42
				.45	.17
				.40	.22
				.50	.12
				.60	.02
				.50	.12
				.90	.28
				.60	.02
				.45	.17
				.65	.03
				.60	.02
				.60	.02

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix B (continued):

Ranks of Deviation Scores

Congenitally Blind	Late Blind	Blindfolded Sighted
46	54	7
34.5	40.5	28.5
64	46	46
75	34.5	75
75	46	34.5
34.5	50	7
75	68.5	75
58.8	7	28.5
75	75	20.5
64	20.5	46
75	64	75
75	7	15.5
75	7	20.5
46	7	7
28.5	24.5	20.5
28.5	64	54
20.5	7	40.5
15.5	54	34.5
64	34.5	58.5
58.5	58.5	64
		50
		20.5
		40.5
		24.5
		15.5
		64
		40.5
		7
		68.5
		40.5
		50
		28.5
		7
		28.5
		54
		7
		40.5
		15.5
		7
		7
R_1 = 1088	R_2 = 796.5	R_3 = 1374.5

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Appendix B (continued):

Computation of H

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3\,(N+1)$$

where k = number of samples

n_j = number of cases in j^{th} sample

N = n_j, the number of cases in all sample combined

R_j = sum of ranks in j^{th} sample (columns)

$\sum_{j=1}^{k}$ directs one to sum over the k samples (columns)

$$H = \frac{12}{80(80+1)} \left[\frac{(1088)^2}{20} + \frac{(769.5)^2}{20} + \frac{(1374.5)^2}{40} \right] - 3(80+1)$$

$$H = \frac{12}{6480} \left(\frac{1183744}{20} + \frac{592130.25}{20} + \frac{1889250.25}{40} \right) - 243$$

$$H = .00185 \left(59187.20 + 29606.5125 + 47231.2562 \right) -243$$

$$H = .00185 \left(136024.9687 \right) - 243$$

$$H = 251.64619 - 243$$

$$H = 8.6461$$

To correct for the effect of tied observations H was divided by

$$1 - \frac{\Sigma T}{N^3 - N}$$

Appendix B (continued):

where $T = t^3 - t$ (when t is the number of tied observations in a tied group of scores)

N = number of observations in all k samples together, that is,

$N = n_j$

ΣT directs one to sum over all groups of ties

Tied rank	7	15.5	20.5	24.5	28.5	34.5	40.5	46	50	54	58.5	64	68.5	75
t	13	4	6	2	6	6	6	5	3	5	4	7	2	11
T	2184	60	210	6	210	210	210	120	24	120	60	336	6	1320

$$1 - \frac{\Sigma T}{N^3 - N} =$$

$$1 - \frac{5076}{80^3 - 80} =$$

$$1 - .0099 = .9900$$

$$\text{Corrected } H = \frac{8.6461}{.9900}$$

$$H = 8.7334$$

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